Discrete Particle Simulation of Wet Powder Flow

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Particulate processes are frequently encountered in many industries: almost three quarters of all industrial products are in a powder form either in their final stage or in their intermediate stage [1]. Such processes include granulation, fluidised bed drying, particle coating, mixing and catalytic reaction. In these powder handling processes, liquid is often added to dry powder to ease powder handling and improve powder characteristics. In such processes, however, even a small amount of liquid can significantly influence the dynamics of powders due to the additional liquid bonding forces exerted between particles. The understanding of wet powder flow is hence of paramount importance to increase the process efficiency.

The Discrete Particle Method (DPM) has been widely used over the past decades to simulate particulate flow and was implemented in OpenFOAM relatively recently, e.g. DPMFoam. In DPM, the inter-particle collision forces are calculated and the motion of the individual powder particles is carefully tracked by solving the Newton's equation of motion to obtain the resultant overall powder flow fields. However, the effect of the liquid is not included in the current DPM solvers in OpenFOAM. In the present work, a modification has been made to the OpenFOAM built-in DPM solvers to make it possible to simulate wet powder flow by taking into account the liquid bonding forces between particles, i.e. the capillary and viscous forces. The developed solver was applied to simulate powder flow in several pieces of process equipment such as fluidised beds and rotary drums. It was observed that the wet powder tends to form clusters and/or lumps of particles whilst the dry powder flows smoothly as shown in Figure 1. The difference in the flow pattern also had a significant impact on the powder mixing.

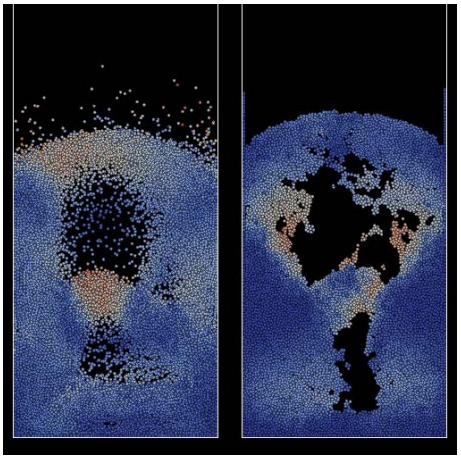

Figure 1. Snapshots of fluidised bed reactors; Dry powder case (left) and wet powder case (right). The colour indicates the particle velocity between 0 (blue) and 1 (red) [m/s]

References

[1] H.G. Merkus, Particle size measurements: Fundamentals, practice, quality, Springer, **2009**.